Space Weather Technical Forecast

Issued on Friday, 10 May 2024 at 00:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G2-G3 (Moderate to Strong) geomagnetic storm conditions expected late 10 May to 11 May with a chance of G4 (Severe) intervals. Further X-class flares (R3 - Strong radio blackouts) likely from AR3664.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is High with a peak flare of X2.2 from AR3664 at 09/0913 UTC and a second strong flare from the same region peaking X1.1 at 09/1743 UTC. Furthermore, occasional M-flares from both AR3664 and AR3663 were observed during the period. There are seven sunspot regions on the visible disc with two regions in the northeast now numbered AR3671 and AR3672. AR3664 remains, by far, the largest and most active flaring region on the disc. Areal extent increased with consolidation of a number intermediate spots within the main penumbral regions and increase in total magnetic flux. The region remained extremely complex with multiple pronounced delta spots. Accurate assessment of AR3663 was increasingly difficult as it approached the northwest limb, but there appeared to be a waning in size and complexity resulting in a slight reduction in classification, although a delta spot configuration was tentatively maintained. The remaining sunspots on the disc are smaller, more stable and magnetically simpler.

Two large halo CMEs were observed leaving the sun on 09 May, associated with flares from the large and complex AR3664 in the southwest disc. The first of these, resulting from the X2.2 flare at 09/0913 UTC was particularly fast and expected to 'sweep up' the numerous CMEs from the 08 May into a combined arrival at Earth late on 10 May. Another CME was in evidence in coronagraph imagery from the X1.1 flare of AR3664 at 09/1742 UTC. This is currently being assessed for any potential Earth-directed trajectory.

Solar Wind / Geomagnetic Activity: Solar winds observed by DSCOVR and ACE at L1 were at slightly elevated levels throughout, declining from 470km/s to 400km/s as the connection to the HSS of CH35/+ continued to ease. Density increased from below average to average levels. The Interplanetary Magnetic Field, Bt, persisted at weak levels (below 7nT) but with a minor transient detected around 09/1730 UTC. The north-south component, Bz, varied weakly between +4/-5nT. Phi angle remained positive (away from the sun). Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) observed at GOES18 was at near background levels, although indicated a slight response to recent flare activity. High energy electron flux (greater than 2MeV) observed at GOES16 was at background to moderate levels. The associated 24-hour fluence was well below the Active threshold. Observed fluence at 10/0001 UTC was 7.96e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: High solar activity is expected to continue, with frequent M-class flares expected and further isolated X-class flares likely, principally from AR3664.

Solar Wind / Geomagnetic Activity: Multiple Earth-directed CMEs were observed leaving the sun between 08 and 09 May associated with solar flares from the large and complex sunspot

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region in the southwest disc. Due to the relative speed of the various CMEs they are expected to combine into a single larger arrival towards the end of the UTC day on day 1 (10 May). Some glancing influence is also possible from a large filament liftoff in the northeast disc on 08 May, this signal likely to be swamped by the previously mentioned CMEs however. Another CME was in evidence in coronagraph imagery from the X1.1 flare of AR3664 at 09/1742 UTC. This is currently being assessed for any potential Earth-directed trajectory.

Outside of CME influence slightly elevated solar winds are expected to fall to background levels on day 1 (10 May). A coronal hole enhancement is possible from late day 2 (11 May) or early day 3 (12 May) onwards although may be masked by lingering CME effects, therefore confidence in observed peak speeds is low.

Geomagnetic activity is expected to remain Quiet to Unsettled early on day 1 (10 May). Later in the day effects from multiple Earth-directed CMEs, as a combined front, are expected to increase activity to G2-G3/Moderate to Strong levels, with a chance of G4/Severe Geomagnetic Storm intervals. Similar levels of activity should persist into the start of day 2 (11 May) before slowly declining towards more typical values by day 3 and 4 (12 and 13 May). Confidence at the end of the period is low and the forecast may change should further large Earth-directed CMEs occur.

Energetic Particles / Solar Radiation: There is an ongoing chance for an S1/Minor Storm or greater event throughout the period associated with significant flaring from AR3663 and AR3664.

High energy electron flux is forecast to be at background to moderate levels throughout, with associated fluence expected to remain well below the Active (1e8 integrated pfu) threshold.

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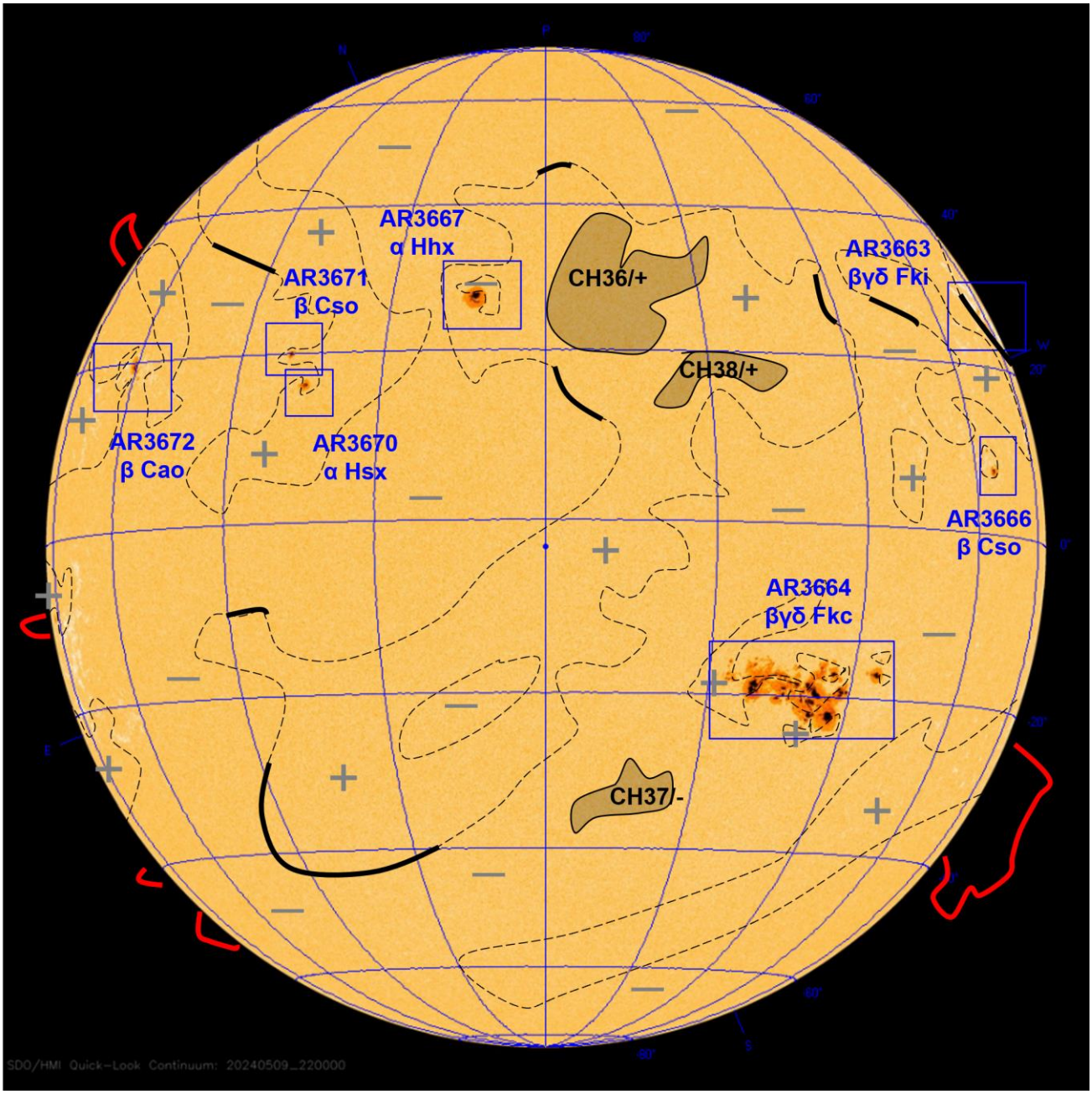
Figure 1. Solar Analysis Valid 09/2200 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A weak transient, likely attributed to the CME from the X4 flare on 06 May is currently passing Earth late on 09 May. Multiple Earth-directed CMEs were observed leaving the sun between 08 and 09 May associated with solar flares from the large and complex sunspot region AR3664. Due to the relative speed of the various CMEs they are expected to combine into a single larger arrival towards the end of the UTC day on day 1 (10 May). There remains some uncertainty in the peak magnitude of geomagnetic activity given complex interaction between the numerous CMEs, however the arrival time of the combined CME front carries much greater confidence. Some glancing influence is possible from a large filament liftoff in the northeast disc on 08 May, this signal likely to be swamped by the previously mentioned CMEs however. Another CME was in evidence in coronagraph imagery from the X1.1 flare of AR3664 at 09/1742 UTC. This is currently being assessed for any potential Earth-directed trajectory.

Outside of CME influence slightly elevated solar winds are expected to fall to background levels on day 1 (10 May). A coronal hole enhancement is possible from late day 2 (11 May) or early day 3 (12 May) onwards although may be masked by the effects of the anticipated significant CME arrival on day 1 (10 May), therefore confidence in observed peak speeds from this enhancement is low.

Geomagnetic activity is expected to remain Quiet to Unsettled early on day 1 (10 May). Later in the day effects from multiple Earth-directed CMEs, as a combined front, are expected to increase activity to G2-G3/Moderate to Strong (Kp6-7) levels, with a chance of G4/Severe (Kp8) Geomagnetic Storm intervals. Similar levels of activity should persist into the start of day 2 (11 May) before slowly declining, likely becoming Active to G1/Minor Storm early on day 3 (12 May) and easing to Quiet to Active during day 4 (13 May). Confidence at the end of the period is low and the forecast may change should further large Earth-directed CMEs occur, primarily from AR3664.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	95	95	80	40
Strong	**G3**	No	60	60	30	10
Severe	**G4**	No	30	30	10	5
Extreme	**G5**	No	10	10	5	1

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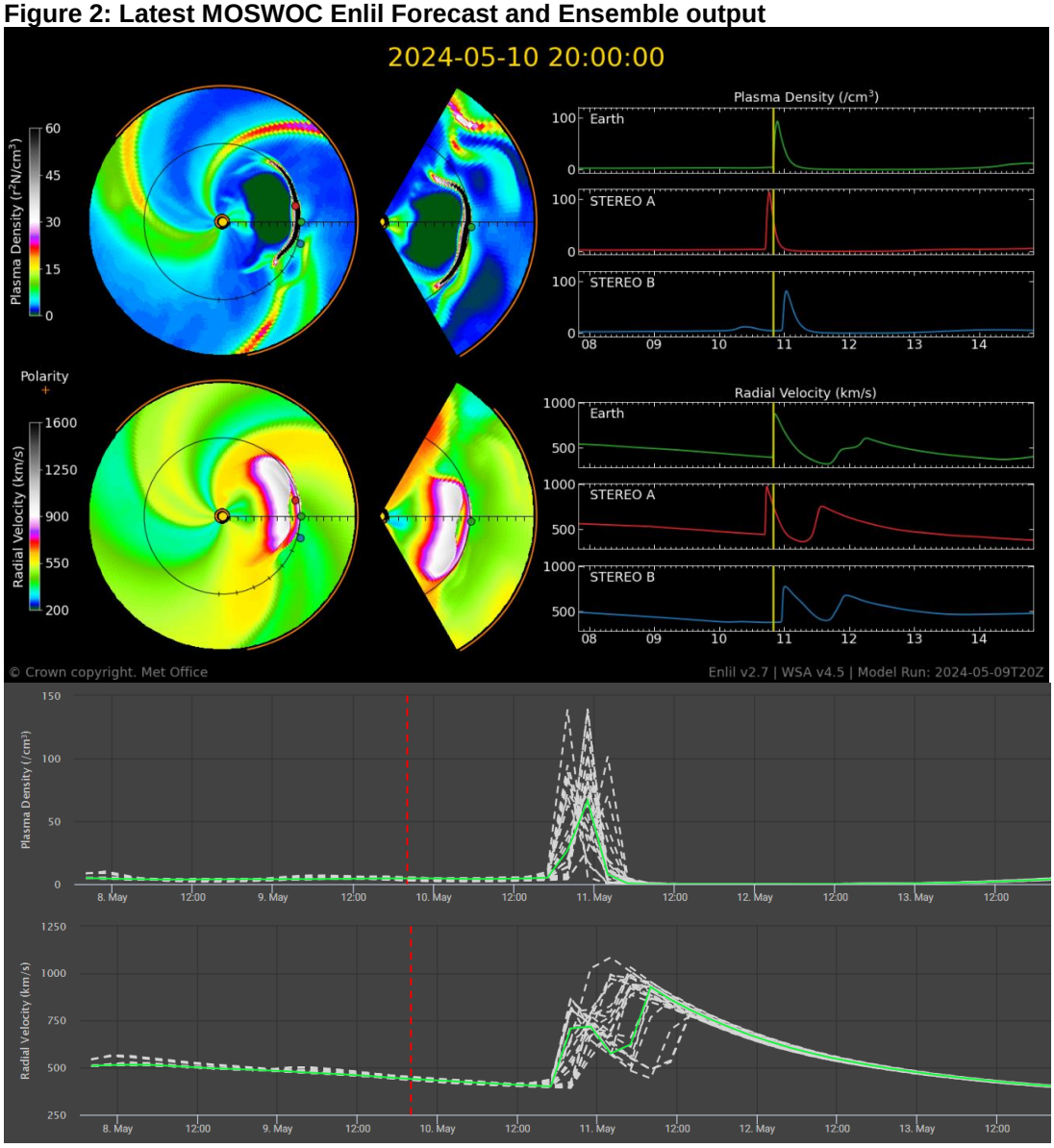
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
06/0251	Partial	Filament	SE	323 km/s	10/1200 UTC	Slight chance glancing blow
08/0927	Full	AR3664	SW	850 km/s	10/2000 UTC +/- 7 hrs	Merges with last CME
08/1200	Partial	AR3664	SW	715 km/s	10/2000 UTC +/- 7 hrs	Merges with last CME
08/1840	Partial	Filament	NE	600 km/s	10/2000 UTC +/- 7 hrs	Merges with last CME
08/2140	Full	AR3664	SW	902 km/s	10/2000 UTC +/- 7 hrs	Merges with last CME
09/1130	Full	AR3664	SW	1582 km/s	10/2000 UTC +/- 7 hrs	Merges with last CME

Figure 2: Latest MOSWOC Enlil Forecast and Ensemble output



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Radio Blackouts - X-Ray Flares:

There are seven sunspot regions on the visible disc, with the two regions in the northeast now numbered AR3671 and AR3672. AR3664 in the southwest remains, by far, the largest and most active flaring region on the disc. Areal increase has slowed in the past 24-hours but with continued consolidation of a number of intermediate spots within the main penumbral regions and increase in total magnetic flux recorded. The region remains extremely complex with multiple pronounced delta spots and potential for large flares. Accurate assessment of AR3663 becoming increasingly difficult as it approaches the northwest limb, with the current classification now likely to be maintained, including a tentative delta spot configuration, until it rotates off the visible disc. The remaining sunspots on the disc are smaller, more stable and magnetically simpler.

AR3663 is due to rotate over the western horizon on day 1 (10 May) with the flare risk form this region then beginning to slowly decrease. Far-sided helioseismographs indicate a number of returning regions over the eastern horizon in the coming days that may supplement the present risk of significant flares should they persist. However as AR3664 currently provides the vast majority of the flare risk and remains on the visible disc throughout, the current risk level is maintained through the forecast period pending further developments.

High solar activity is expected to continue, with frequent M-class flares expected and further isolated X-class flares likely, principally from AR3664.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	95	95	95	95
Very Active	R3 to R5 X Class	Yes	60	50	50	50

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Figure 3a: Latest GOES16/18 X-Ray flux

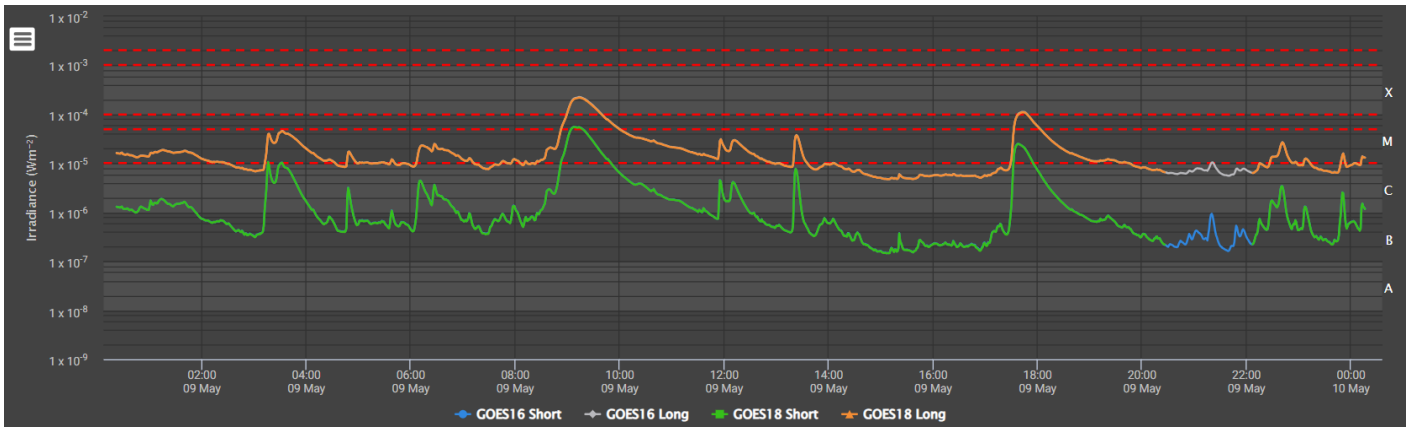
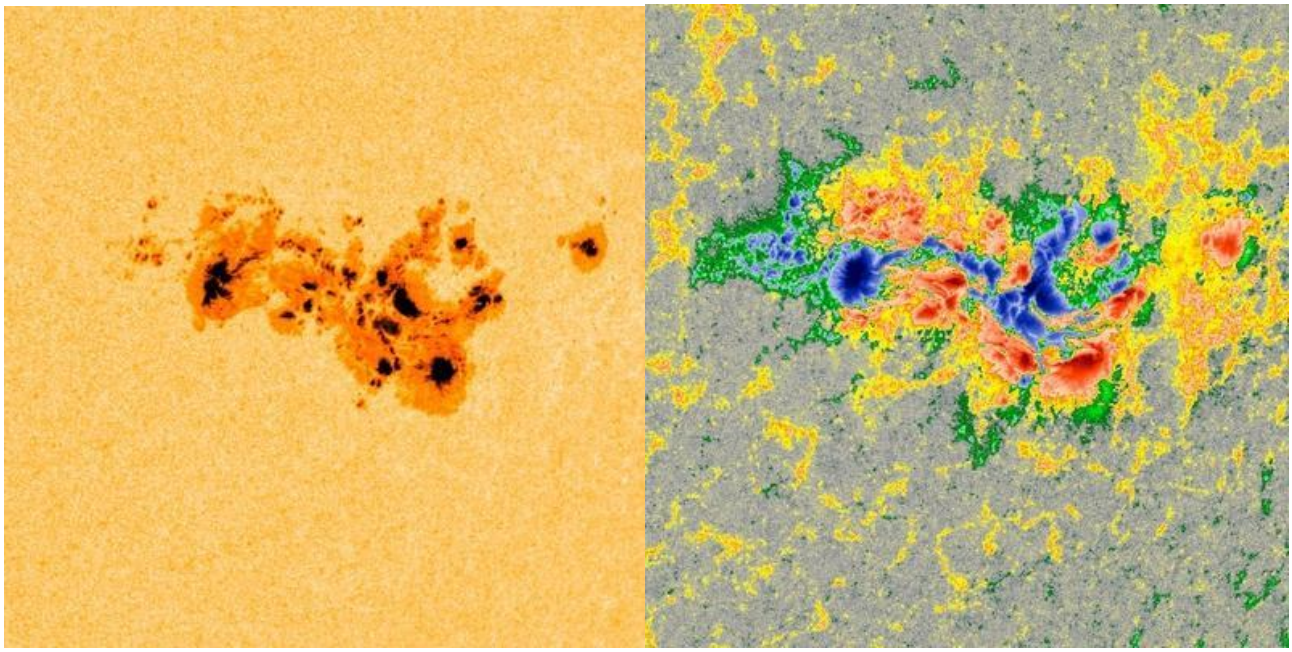


Figure 3b: HMI Intensitygram – Flattened (left) and HMI Colorized Magnetogram (right) of AR3664



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Solar Radiation Storms - (High Energy Protons):

High energy proton flux (greater than 10MeV) observed at GOES-18 is at near background levels despite recent significant flaring. There is a chance however of an S1/Minor Storm or greater event occurring on all days, from both AR3663 as it rotates around the northwestern limb in the coming days and increasingly from AR3664 as this region moves further across the southwest disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	40	40	25	25
Very Active	**≥ S3 ***	No	5	5	5	5
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux is at normal background levels. Forecast CME and coronal hole influence through the period is expected to limit electron flux to background to moderate levels on all days.

Overall, the 24 hour integrated electron fluence is forecast to remain well below the Active (1e8 integrated pfu) threshold. The Met Office REFM model is considered to be giving good guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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Figure 4: GOES16 Electron Flux (above) and MOSWOC REFM forecast and recurrence (below)

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